Controlling and investigating domain and domain walls in $PbTiO_3$ ferroelectric thin films and heterostructures

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$PbTiO_3$ is a material that exhibits a bulk paraelectric-ferroelectric phase transition at a critical temperature T_c of 765 K, with a polarisation that develops along the c-axis mostly due to ionic displacements. Theoretical studies of domain structures in $PbTiO_3$ thin films have revealed complex phase diagrams with regions of distinct domain configurations as a function of different parameters [1].
We study the domain configuration in $PbTiO_3$ heterostructures, epitaxially grown on $(110)_o$-oriented $DyScO_3$ substrates, with bottom and top $SrRuO_3$ electrodes using a combination of atomic force microscopy, laboratory and synchrotron x-ray diffraction, and high resolution scanning transmission electron microscopy. We observe a large asymmetry in the domain configuration due to the anisotropic strain imposed by the orthorhombic substrate, and we find that the periodicity of the domain wall deviates from the Kittel law. As the ferroelectric film thickness increases, the domain configuration evolves from flux-closure to an a/c-phase, with a larger scale arrangement of domains into superdomains [2].
Moreover, above a critical value of $PbTiO_3$ thickness, we observe a modulation in the structure of the top $SrRuO_3$ electrode, demonstrating the possibility of domain nano-engineering via structural coupling to ferroelastic domains [3].

[1] Schlom et al., Annu. Rev. Mater. Res., 37, 589-626 (2007).
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[3] Lichtensteiger, ..., L.T. et al., APL Mater. 11, 101110 (2023).